

[Box, p 10]

- 1964. The American navigational satellite Transit with a radioisotope power source on board is not able to achieve orbit. The device with plutonium-238 breaks up in the atmosphere and is dispersed across the globe. Around 17,000 curie of plutonium-238 was released into the environment, three times more than its content of this isotope.
- 1965. The only reactor placed in space by the U.S. malfunctions after 43 days. Even though the satellite was moved to a high, long-duration orbit, according to certain reports, it had already begun to fall apart.
- 1968. The American weather satellite Nimbus, containing plutonium energy sources, suffers greatly from an unsuccessful launch. These energy sources fall into the ocean not far from Santa Barbara (California). They are found five months later.
- 1969. Two unmanned devices are launched by the USSR in the autumn to investigate the moon. Several days after the launch, both return to the atmosphere. It is believed that one or both of them carried polonium-210: according to certain reports, radioactivity was detected in the atmosphere after the return of the vehicles.
- 1970. The Apollo 13 moon flight fails. The lunar module is jettisoned and lands in the Pacific Ocean with its plutonium power-support unit on board.
- 1973. Due to an accident during launch, a Soviet satellite with nuclear reactor on board falls into the Pacific Ocean north of Japan.
- 1978. Possibly the largest accident thus far: Cosmos 954 enters the atmosphere and breaks apart, scattering thousands of radioactive fragments over 100,000 square kilometers in the northwestern regions of Canada. The Soviet Union pays Canada sizeable monetary compensation.
- 1983. The radioactive core of the reactor of Cosmos 1402 returns to the atmosphere, breaks up, and disperses its radioactive reserves.
- 1988. Radio communications with Cosmos 1900, launched in July 1987 and carrying a nuclear reactor on board, are lost in April 1988. The absence of communications prevents sending it a command to move to high orbit, and by the middle of September of the same year it slowly loses altitude, gradually coming closer to earth. Only on 30 September, several days before entering the dense layers of the atmosphere, is the protection system activated, and the satellite ascends to a safe stationary orbit.

(Taken from an article by D. Hirsch, president of a working group on use of nuclear energy in space, of the Federation of American Scientists: "Soviet Reactors for SDI?" MEZHDUNARODNAYA ZHIZN [International Life], No 12, 1989).

Ponomarev-Stepnoy Rebuts Arguments of Nuclear Dangers in Space

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[Second article of two-article spread: "Onward to Nature!"; article is by USSR Academy of Sciences Academician N. Ponomarev-Stepnoy, deputy director of the Institute of Atomic Energy imeni I. V. Kurchatov]

[Text] Accidents with Soviet and American satellites carrying nuclear power sources have greatly agitated world opinion. This alarm became especially acute after the mishap with Cosmos 954 in 1978 and the almost disastrous failure of Cosmos 1900 ten years later. The result—a strong movement against nuclear reactors in space.

People's fear of another Chernobyl—wherever the threat might be, in space or on Earth—is a very grave matter that cannot be assuaged with assurances like "My word of honor, there won't be any more explosions." It is not surprising, therefore, that scientists engaged in nuclear power engineering (particularly that in space) appear to be medieval "vivisectionists" or "mad professors" from a Hitchcock horror movie in the eyes of the majority, who have lost faith in science. Since I am now professing the necessity of nuclear power in space, I am afraid that I, too, will be put in that category. It is therefore gratifying that the debate with my opponents (especially R. Sagdeyev) has become worthy of the press. This allows both sides a chance to express their opinions.

As strange as it may seem, my position and that of Roald Zinnurovich [Sagdeyev] are more similar than they are different. We both consider the first and essential condition for development of space-based nuclear technologies to be their safety, but we use semantically opposite imperatives: one side says "Yes, they may be used, with the exception of such and such instances"; the other actually reiterates that by saying "In such and such instances, they may not be used." The main difference is in the intent: "to prohibit, because it is dangerous" versus "to permit when it is safe."

Really, I have no faith whatsoever in the effectiveness of such prohibitions. However enticing from the standpoint of safety the slogan "Back to Nature!" may appear, it is not true, if only because it cannot be carried out. Much more logical, in my view, is the slogan "Onward to Nature!"—to a Nature protected against the sinister consequences of scientific and technical progress by scientific and technical progress itself.

Man's drive to outer space, like the process of learning itself, may be prohibited, but it cannot be prevented. In one way or other, space will be developed—on this score, it would appear, no one expresses any doubt. The main training ground for the space program today is near-Earth orbit. A multitude of problems are being worked out there at present—problems that are purely scientific,

as well as those that are principally applied (communications, meteorology, geology, navigational support, development of revolutionary technologies, etc.). The next step is the conquest of the distant orbits and flight to other planets. None of these missions could be performed without a suitable energy supply, and the greater the distance, the more necessary this becomes.

The energy requirements of the space program today are measured in kilowatts and, at rare times, in tens of kilowatts. Tomorrow, hundreds will be needed—for the same development of technologies. And expeditions will require megawatts. Where will we get them? Neither wood, nor coal, nor wind engines, nor heated water are, of course, appropriate. The energy sources available in space can be counted on one hand. There are three—chemical, solar, and nuclear.

Chemical energy sources are good when it is a question of a short time of operation in space (on the order of several days or weeks). When the spacecraft is required to operate for months or years, the weight of the chemical fuel components that must be placed in orbit becomes a serious hindrance. The best solution in this case is to use the energy of the sun. All of this relates to comparatively low levels of energy consumption (on the order of 10 or 20 kilowatts). As soon as more energy is needed, one must also abandon solar batteries. Not only because of the increasing weight, but also because the controllability of the space vehicles is drastically impaired by the large areas of the photocells.

Thus, for long periods of time and large energy expenditures, nuclear sources have no replacement. Of course, that does not mean that they should be used everywhere, if there is a reasonable alternative. The important thing is the question of safety, and therefore we should immediately remove from the "purview" of nuclear power those cases in which it might lead to fallout of a dangerous quantity of radioactive substances on Earth. For example, satellites with nuclear reactors on board should not be launched in low near-Earth orbits, since over time they might lose altitude and return to earth in the form of radioactive fragments.

Yet, space itself furnishes us with a unique opportunity to perform a kind of "ecological" exploration of the questions of safety and application of nuclear energy in space. The safety of a space vehicle with a nuclear energy source on board is automatically secured if the ballistic characteristics of its orbit prevent the vehicle from reaching Earth for several hundred years. Our opponents declare that even here, in the high orbits, nuclear engineering should be prohibited, since there exists a finite probability of the space vehicle colliding with the fragments of defunct satellites and subsequently returning to Earth. Such an argument, in my opinion, does not suit a scientific debate. The magnitude of such a probability, although it is finite, is very small at present. Unfortunately, I am not myself able to give the specific figure

either, since it is the result of very hypothetical calculations; but neither that probability nor the present experience with outer space (since 1957, despite a huge number of launches, not a single collision has been detected) gives us reason to believe that the likelihood of a collision is large enough that one may be expected for, say, centuries. This probability must be computed, of course, and we are working on that today. In January, at a conference in Albuquerque, we talked with American scientists about organizing this work together.

Naturally, the safety of space vehicles with nuclear reactors on board has not always gone smoothly—this is evident from the list of accidents presented here. But over the course of time the safety systems have been improved (and are continuing to be improved), as a result of which, incidentally, the incident involving Cosmos 1900 had a good ending. Cosmos 1900 was outfitted with several emergency systems. It was to be expected that one of these might fail (the first system failed), but it is much harder to imagine a situation in which all systems would fail. Of course, equipment failures like that which occurred in Cosmos 1900 are intolerable, but I would not, as did our opponents, declare the satisfactory outcome of the incident a miracle. The opposite, perhaps, would have been a miracle (of an opposite nature).

As a matter of fact, in my opinion, the arguments presented against nuclear power in space are not always justified, nor are they always valid. For example, it is hard for me to understand how a person who is competent in engineering could compare the long-term effects of an accident involving a space nuclear reactor and the long-term effects of an accident involving a reactor like the one that blew up in Chernobyl. The capacity of the first is around 100 kW, whereas the capacity of the Chernobyl power unit was 1000 MW. The total radioactivity of the reactor is proportional to the energy produced.

And I have no idea what to make of the recent statement in the press that said that last year Soviet scientists offered the Americans their own nuclear reactor for use in SDI. In actuality, the reverse is the case: for already a year the scientists of the USSR and the United States have been studying very carefully the issue of changing-over space technology, including nuclear power engineering, from military to peaceful objectives. Last year, the American company Space Power, Inc., came to us with a proposal to create by joint venture a satellite for worldwide broadcast of high-resolution television programs, multichannel telephony, and navigational support of all kinds of air and marine transport. The value of such a satellite to all the inhabitants of Earth is hard to exaggerate—it represents a qualitatively new level of communications, an immeasurably greater degree of safety for airplanes and ships. But such multichannel system requires appreciable power, which can only be provided by a nuclear reactor. In January 1990, at a conference in Albuquerque, these negotiations were resumed. Incidentally, one other very interesting and, in

my view, extremely imaginative project using nuclear reactors was discussed there—use of nuclear reactors not in outer space, but on the surface of the Moon, to provide the energy for future colonies.

I repeat: I can only welcome any open debate on the possibilities and dangers of nuclear power in space. I do not at all consider my point of view to be the last and final truth, and I am ready to change it, if reasonable and scientifically grounded objections are presented. But I have yet to hear any. I have always felt, and still do, that it is more proper to safeguard the operation of a needed piece of equipment than to ban it.

Conference on Nuclear Power in Space Opens

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[TASS Report: "Conference on Nuclear Power"]

[Text] Obninsk (Kaluga Oblast), 15 May—An industrial scientific conference "Nuclear Power in Space," organized by the USSR Ministry of Nuclear Power Generation and the Nuclear Industry, began work here today.

Every step that mankind takes in exploring space demands a significant expenditure of energy. Until now the only source of energy aboard spacecraft has been solar batteries. The first thermal emission nuclear electric power installation in the world, "Topaz," which is a power plant to be used on board craft intended for work in inner and outer space, has recently been successfully tested in the Soviet Union. The main participants in developing it are the Physical Energy Institute where the conference is being held and the "Krasnaya Zvezda" science and production association.

Leading specialists from the Soviet Union, the United States, France, Great Britain, the FRG, and Holland are participating in the work of the conference. The most important tasks facing them include guaranteeing total radiation safety in the operation of the nuclear reactor in space.

Deep Space Communication Center at Yevpatoriya

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[Article by B. Sopelnyak, special TASS correspondent, for KRASNAYA ZVEZDA: "The Secret of Facility MV"]

[Text] The formidable warship was reaching the end of its days. The flag was already lowered, the crew was already transferred to shore, but neither the sailors nor the officers had left the pier—they simply could not believe that they were seeing for the last time the ship that had become their home, that it had been ordered, as they say in the navy, to be rafted down the river to splinters. Someone recalled that the pride of the Russian and Soviet navy, the battleship Sevastopol, had taken

part in the heroic defense of the city, in whose honor it was named; another one went even further in his reminiscences...

When the towing hawser had been attached and the ships standing alongside mournfully blew their whistles, a group of civilians appeared on the pier, accompanied by two admirals. A stout with a big forehead and a dark coat glanced at the ship with an imperious look and said curtly: "As you were!"

The admirals immediately rushed to carry out the command. The man in the dark coat went on deck, moved around the main gun turret, carefully regarding the 305-mm guns. He kicked the armor for some reason and then turned to his slender, gray-haired companion.

"What do you think, Mstislav Vsevolodovich, will it do?"

"It will, Sergey Pavlovich. It will do quite well!"

Thus, the gun turret of the battleship destined for the scrap yard was given a new life. And what a life!

The late fifties... The first artificial Earth satellite had just been launched, the amiable Layka had not yet been to space, a manned spacecraft had not yet gone up—and even so, S. P. Korolev and M. V. Keldysh were already making calculations for flights to the Moon, Mars, and Venus and were dreaming about the probing of deep space. In December 1957, an article by Korolev appeared in PRAVDA under the pseudonym K. Sergeyev. In it he wrote: "There is no doubt that the quest for new and better space rockets will continue, unmanned spacecraft will be developed, and, finally, other planets will be reached."

Korolev's vision came true, as it were, right before everyone's eyes. Ultrapowerful rockets were built, spacecraft were developed, and satellites went into the uncharted reaches of space. But how was all of this to be controlled? How would the incoming information be received and processed? It was at this time that a project was undertaken to build "eyes and ears," as well as "arms," that would reach out to the spacecraft and satellites—an antenna for deep-space communications. The deadline was eight months. No one had any experience with such matters, and there were only a handful of specialists, but Korolev's people took up the task enthusiastically. A site was selected outside Yevpatoriya, right on the seashore. A crater was dug out of the rocky ground, the foundation poured, and one of the enterprises made eight "dishes" of 16-meter diameter. But what would they be mounted on? After all, an antenna is supposed to rotate in all planes. And that's when Korolev thought of the battleship... The gun turret was placed right on the foundation; on top of that, the open framework of a railroad bridge; on the frame work, the solid hull of a scrapped submarine; and on the hull, finally, the eight antenna "dishes."